Physics 2710 General Information

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Course web page: http://physics.weber.edu/schroeder/modern/
Office hours: MWF 10:30 – 11:20 am. I'll often be available at other times as well, though usually not on Tuesdays or Thursdays. My complete schedule is posted next to my office door. Feel free to make an appointment if you need to talk with me at a particular time.

Textbooks: For the relativity portion of the course (during the first four weeks), our text will be *Six Ideas that Shaped Physics*, *Unit R*, by Thomas A. Moore (McGraw-Hill, 2002). For the remainder of the course you'll need a more traditional "modern physics" textbook. Any such textbook is acceptable. I especially recommend *Modern Physics for Scientists and Engineers* by Taylor and Zafiratos (Prentice Hall, 1991 or 2004).

Course Outline

The theories of relativity and quantum mechanics, together with their many applications, are often called "modern physics," as opposed to the "classical physics" that preceded them. Now that these subjects are 100 years old, the word "modern" is becoming a bit of a misnomer. Still, relativity and quantum mechanics continue to serve as the foundations of 21st-century physics. And these subjects are truly revolutionary: They defy common sense, forcing us to re-think our most basic assumptions about space, time, motion, and measurement. The purpose of this course is to study these subjects in as much depth as is possible in a semester-long course with a year of calculus as a prerequisite.

1. **Relativity.** You already know that relativity shakes up our understanding of time, space, and motion. In this course you will master the theory—both its kinematic (time and space) and dynamic (energy and momentum) portions. You'll learn to apply relativity to precision measurements, subatomic physics, and interstellar travel.

2. **Quantum Mechanics in One Dimension.** Quantum mechanics tells us that we need to describe the state of a particle with a wavefunction, rather than precise values of position and momentum. First you'll master most aspects of quantum mechanics in one dimension: wavefunctions, probabilities, energy quantization, and tunneling.

3. **Quantum Mechanics in Three Dimensions.** Quantum mechanics in 3-D gets more complicated, so we'll have to pick and choose our topics and often rely on a more pictorial approach. Our goals will be to understand angular momentum (including spin), the hydrogen atom, and the qualitative features of multi-electron systems.

4. **Seminar in Contemporary Physics.** We don't have time to cover all the rest of modern physics in depth, so the last part of the course will instead be organized in seminar format, with presentations by various speakers including you and your classmates. Advanced theoretical topics may include general relativity, foundations of quantum mechanics, nuclear physics, and elementary particle physics. Further applications may include multi-electron atoms, chemical bonding, properties of solids, lasers, and selected topics in nanotechnology, biological physics, and astrophysics.

Goals* of the Course

I'd rather teach you *how* to think than *what* to think. Physics is not so much a collection of facts as a *way* of looking at the world. My hope is that this course will not only teach you the *ideas* of relativity and quantum mechanics listed above, but will also improve your *skills* in careful thinking, problem solving, and clear communication. In this course you will practice and refine your skills in mathematical problem solving using calculus; using a computer to help solve math problems; making rough numerical estimates and more accurate calculations; and communicating the ideas of physics, both qualitatively and quantitatively, through words, pictures, and equations. When you can apply all these skills to a broad variety of situations, you are "thinking like a physicist" (as we like to say). Whether or not you choose to become a professional physicist, these skills will serve you well for the rest of your life.

Policies and Procedures

Class sessions for the first 3/4 of the course will be spent on lecture, demonstrations, example problems, and discussion. *Please feel free to interrupt with questions at any time.* Suggested reading assignments from our textbooks are indicated on the class schedule; you may decide whether you benefit more from reading this material before or after class. Class attendance during this portion of the course is not required, but is strongly recommended. The last 1/4 of the course will be run as a "seminar" in contemporary physics, with presentations by students and guest speakers. Attendance at these sessions *is* required and will count toward your grade.

Problem sets will be assigned roughly once a week, as indicated on the daily schedule, and will be due (in my office or mailbox) at 5:00 p.m. The purpose of the problem sets is *not* to test you; rather they are an opportunity for you to practice and learn. I *strongly* encourage you to work with classmates on problem sets. In this way you can learn from each other, prevent careless errors, practice putting ideas into words, and work in an environment more like the "real world." You are also welcome to ask me for hints at any time. However, the work that you turn in must be entirely your own. While you may discuss the problems with others as much as you like, you may *not* look at anyone else's written solution (including any solutions published on the Internet or elsewhere) until after you have turned in your own. When you receive significant help from a anyone on a particular problem, you must give that person credit in your written solution.

I will grade each problem set on a scale of 0 to 4, with the score based not only on your getting the right answers but also on the completeness of your solutions and on how well you communicate on paper. Your solutions should be written so that any classmate could read and understand them. Solutions that are incomplete, illegible, or poorly organized will receive significantly less credit, even if the answer is correct. I will make official solutions to each problem set available soon after the due date.

Late problem sets will not be accepted. However, your homework grade will be based on only the highest 8 (out of 9) problem set scores, so you may miss one problem set without penalty. This policy should give you enough flexibility to deal with most illnesses, family emergencies, term papers, unexpected romances, and the like; exceptions will be granted only in the case of very serious illness or other long-term crisis, and then only if you contact me as soon as possible.

Projects

During the last two weeks of the course, each of you will write a paper and give a 15-minute presentation to the class, on a modern physics topic or application of your choice. See the separately attached page for details.

Tests

We will have three **midterm tests**, given in the science testing center (SL 228). They will be closed-book, but you may use a calculator for doing arithmetic. The time limit on each test will be 90 minutes, and you will have approximately two days during which to take each test.

No make-up exams will be given without *advance* permission.

Grades will be computed according to the following weights:

Problems sets (highest 8)	32%
Three midterms @16%	48%
Projects and seminar attendance	20%

In deciding borderline grades I may also consider class attendance (during the first 3/4 of the course) and participation. It is your *effort* at participation that matters; how much knowledge you demonstrate makes no difference at all.

Academic dishonesty, though rare, occasionally does occur in physics classes, so the following policies are necessary. Dishonesty on a homework assignment will result in a zero grade for that item on the first occurrence and failure in the course thereafter. Dishonesty of any sort on a test, if clearly documented, will result in automatic failure in the course. In serious cases, evidence of dishonesty may also be presented to the appropriate hearing committee for possible further sanctions.

Special notice: Any student requiring accommodations or services due to a disability must contact Services for Students with Disabilities (SSD) in room 181 of the Student Service Center. SSD can also arrange to provide course materials (including this syllabus) in alternative formats if necessary.

Hints and Suggestions

The ideas of relativity and quantum mechanics are the among most interesting and fundamental in physics, but they are also extremely abstract, far from our common experience. Nobody is born with an intuitive understanding of these ideas; the only way to develop intuition is to *practice* repeatedly with each new concept. Your best chance to do this will be on the problem sets, but I also advise you to wrestle actively with the concepts as you read the textbooks, ask questions during class, and discuss physics outside of class.

Because of the abstractness, and the sequential nature of the course material, it is crucial that you not fall behind. If you don't understand something I say in class, ask immediately. Read the texts regularly, and don't postpone homework until the last minute. This is not a course in which you can successfully procrastinate for weeks and then learn everything the night before the test. A bit of rote memorization might be necessary at times, but it won't help you at all with the major principles.

Nobody finds it easy to learn relativity or quantum mechanics: remember that even the greatest theoretical physicists never dreamed that the universe could be so bizarre, until these ideas were forced upon them by experimental evidence. Fortunately, like all ideas in physics, relativity and quantum mechanics are *not* all that difficult, once you understand them. I hope that, by the end of this course, you will recognize much of the underlying simplicity of the most basic laws that govern our universe.

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*A memo in my mailbox from the Powers That Be states that "goals" are now to be referred to as "learning outcomes."

Physics 2710 Student Projects

During the last few weeks of the course, each of you will study a modern physics topic of your choice, make a 15-minute presentation to the class on this topic, and write a formal paper presenting what you have learned. The idea is to give you a chance to explore a subject that interests you in some depth, while exposing the whole class to the breadth of modern physics. You'll also gain some practice in communicating science, in an environment where there is much less pressure than in a senior seminar or job interview.

Please start thinking now about possible topics. Your topic must be an application or extension of something that you've already learned in this class, that is, of relativity or quantum mechanics. The topic must also lend itself to a presentation and paper at the level of this class—neither too elementary nor too advanced. Your presentation and paper must include some honest calculations—not just descriptions—yet must be fully understandable to your classmates.

Many of the best project topics are discussed in your textbook, in sections that we will otherwise not cover in class. Your textbook covers a wealth of applications to atomic physics, molecules, solids, nuclei, and elementary particles. (Please avoid topics such as statistical mechanics that are more appropriate for a course in a different branch of physics.) Many other suitable topics are not in your textbook but are reasonably easy to research in the library or on the Internet. Here are a few off the top of my head: relativistic electrodynamics; The Schwarzschild metric; GPS satellites (relativistic effects); Bell's theorem; quantum cryptography; nuclear magnetic resonance; radiation safety; nuclear medicine; particle accelerators; structure of the proton; Feynman diagrams; quantum electrodynamics; neutrinos; dark energy. Please consult with me as you choose a topic, look for sources of information, and pin down the scope of your project.

To deliver your presentation you should use Powerpoint or some similar presentation software. Plan on preparing between 8 and 12 slides, depending on how much is on each of them. Prepare your slides to be clear and legible, but don't spend a lot of time making them pretty or distract your audience with visual frills. Be sure that your slides include all of the visual information you need; writing on the blackboard is not an option when you have only 15 minutes.

Here are some important dates and deadlines for preparing and delivering your project:

- Friday, October 26: Starting at the beginning of class today, I'll take written proposals for presentation topics on a first-come, first-served basis. If you don't want someone else to choose your favorite topic, get your proposal in soon! Your written proposal must include a title, the name of at least one specific topic in the course that your project will build upon, and a citation to at least one good reference (book or article) on the information you will be presenting.
- Friday, November 9: Deadline for submitting your project proposal (in writing). Again, your written proposal must include a title, a specific course topic that your project will build upon, and at least one good reference.
- Friday, November 16: I'll distribute a schedule showing the exact date of each presentation.
- Wednesday, November 21: Turn in a one-page typed summary of what you plan to cover (including a detailed outline). Schedule an appointment for practicing your talk.
- At least three school days before your presentation: Practice giving your talk (to me).
- November 28 – December 7: The presentations themselves.
- Monday, December 10: Turn in your typed paper by 5:00 pm.

I will grade your project based on all of the elements just described: how much you have learned, how effectively the presentation was delivered, whether the presentation and paper are well prepared and at the right level, and whether you meet all the deadlines. For students who make a conscientious effort and do not procrastinate, I expect the presentation grades to be quite high. You will also receive credit for attending your classmates' presentations and the special lectures (and any other special activities) that precede them.